



# New I/O Management Best Practices for Oracle® Database Quality of Service

Optimizing performance, compliance, and cost for OLTP and OLAP workloads in traditional and virtualized environments

## At a Glance

Oracle and Emulex® have partnered over the years to meet the requirements of the most demanding data centers. During this time, Oracle Database quality of service (QoS) requirements have resulted in the identification of Best Practices in Input/Output (I/O) management and performance. Emulex LightPulse™ LPe12000 8Gb/s Fibre Channel Host Bus Adapters (HBAs) are central to optimizing performance, compliance and cost for OLTP and OLAP workloads in traditional and virtualized environments. This White Paper provides 15 Best Practices to help all storage administrators in any data center get the most out of their Oracle deployments, while minimizing the cost to achieve the required QoS.

## Oracle Products

- Oracle 10g and 11g
- Oracle Enterprise Linux
- Oracle Real Application Clusters (RAC)
- Oracle VM

## Emulex Products

- Emulex LightPulse LPe12000 8Gb/s Fibre Channel HBA
- Emulex OneSecure™ 8Gb/s Fibre Channel Encryption HBA
- Emulex OneConnect™ Fibre Channel over Ethernet (FCoE) Converged Network Adapter (CNA)
- Emulex OneCommand Manager
- Emulex OneCommand Vision

## Applications

- Oracle Database including data warehouse capabilities
- Compliance, encryption, and data integrity

## Introduction

Exploding data, expanding IT-as-a-service model and increasing alignment of IT and business missions has put a sharp focus on meeting QoS requirements in both physical and virtual environments. Nowhere is this challenge greater than with Oracle databases and the myriad OLTP and OLAP workloads that they enable. The traditional notion of QoS is now expanding to include service level agreements (SLAs) for availability and compliance.

The key for all these database QoS requirements is in a well-tuned I/O infrastructure across networked storage—but this is often very difficult since it spans multiple IT groups: Database Administrators (DBAs), Server Administrators, Storage Administrators, Compliance and Security Specialists and, increasingly, Network Administrators (for converged network environments). The good news is that one of the easiest, most effective places to optimize and manage I/O is on the host, where the application drives the data, and in particular through the HBA.

For server and storage administrators supporting Oracle databases, including the latest 11g Release 2 version, this Best Practices White Paper provides 15 powerful tips and tricks to optimize overall I/O performance, maximize compliance and minimize cost in both traditional and virtual workloads.

## Oracle Database Best Practices

These Oracle Database Best Practices focus on the following requirements:

1. Optimize I/O throughput and response times in traditional and virtual deployments
2. Reduce costs (server, licensing, management, security) while maximizing server performance
3. Ensure regulatory compliance for sensitive data workloads

These three key requirements stand out as the ones that most impact Oracle users as they try to fully utilize their Oracle deployments. Maximizing CPU utilization of existing servers is required and, in fact, is key to keeping costs down as fewer servers are needed. Moreover, to provide the service levels required of the business operations so that revenue is maximized and OLTP response time is minimized, I/O to each database must perform at its peak. Meeting regulatory requirements for sensitive data needs to occur without impacting I/O performance.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

Many data centers still rely on a 4Gb/s connectivity storage infrastructure. With plans to upgrade in the future, these data centers can, meanwhile, upgrade certain components of their networked storage to address database and server performance needs in the short term which will, in turn, keep server acquisition and licensing costs down. Similarly, solutions that off-load CPU processing, such as for encryption, reduce host CPU processing, allowing each server to do more transaction processing and can reduce application licensing costs.

With so much information to obtain and digest, it is useful to have Best Practices identified. For each of the key areas above that are very important to most Oracle users, the following Best Practices are described in this White Paper:

## 1. Optimize I/O throughput and response times in traditional and virtual deployments

- 1.1 Best Practice: Implement 8Gb/s Fibre Channel HBAs in 4Gb/s environment (pg. 3)
- 1.2 Best Practice: Maximize 8Gb/s Fibre Channel HBAs performance with 8Gb/s I/O path (pg. 3)
- 1.3 Best Practice: Maximize OLTP performance with 8Gb/s Fibre Channel HBA (pg. 3)
- 1.4 Best Practice: Use NPIV to maximize Oracle performance on virtual machines (pg. 4)
- 1.5 Best Practice: Use dual port and quad port HBAs to maximize Oracle performance on virtual machines (pg. 4)
- 1.6 Best Practice: Manage and tune real-time I/O performance (pg. 5)
- 1.7 Best Practice: Always download the latest Emulex driver when installing and configuring an HBA (pg. 6)

## 2. Reduce costs (server, licensing, management, security) while maximizing server performance

- 2.1 Best Practice: Tune your 8Gb/s Fibre Channel HBA for maximum performance (pg. 7)
- 2.2 Best Practice: Increase operational efficiency with management solution (pg. 8)
- 2.3 Best Practice: Use Graphical User Interface (GUI), Linux sample scripts and customized scripts (pg. 9)
- 2.4 Best Practice: Offload encryption processing to the OneSecure adapter for a cost-effective security solution with zero impact to applications processing (pg. 9)

## 3. Ensure regulatory compliance for sensitive data workloads

- 3.1 Best Practice: Secure data in-flight and at-rest on disk (pg. 10)
- 3.2 Best Practice: Encrypt data as close to where data is created—at the host (pg. 10)
- 3.3 Best Practice: Hardware protection of encryption keys (pg. 10)
- 3.4 Best Practice: Use standards-based security solutions for interoperability (pg. 11)

## Oracle and Emulex Partnership

With a partnership spanning a dozen years, Oracle and Emulex have long collaborated on, and delivered, enterprise solutions that address the most pressing needs of IT managers. A good example of this is the Data Integrity Initiative (DII). Emulex, Oracle and storage vendors are driving DII, a technology collaboration aimed at bringing to market the first application-to-disk data integrity solution, based on the ANSI T10 Protection Information (also known as T10 Data Integrity Field (DIF)) standard. Although undetected data errors are rare, the costs can be extremely high when they do occur. All Emulex HBAs perform error checking to ensure the integrity of data as it passes through the adapter. However, the potential exists for data errors to occur in other parts of the I/O path.

Emulex has partnered with Oracle to provide new levels of data checking throughout the full data path from the application layer to the storage array. As a first step, Emulex is an exclusive partner with Oracle's recently launched Data Integrity offering for enhanced data integrity based on Emulex BlockGuard™ technology that is supported with 8Gb/s Fibre Channel HBAs. Checksums are added when data transmissions are originated by Oracle and then validated by the HBA firmware. This ensures that any errors resulting from the server and software stack are detected and corrected. The same applies to data that is passing back to the application. With the Oracle "optimized kernel" version of Oracle Enterprise Linux, Data Integrity is quickly becoming a reality.

Over the years, Oracle and Emulex have fully tested and certified Emulex adapters with Oracle hardware and software products. Oracle Enterprise Linux, Oracle VM and all Oracle Database and RAC have supported Emulex adapters since day one. Furthermore, Emulex is part of Oracle's Unbreakable Linux Program and participates in Oracle's Validated Configuration Program to offer robust connectivity solutions for Linux deployments for our joint customers. Listed in Oracle's Solutions catalog, Emulex, through its strong partnership with Oracle, ensures that Oracle end-users have a fully supported, robust Fibre Channel Storage Area Network (SAN) and converged network.

## 1. Best Practices to optimize I/O throughput and response times in traditional and virtual deployments

Oracle databases are designed to maximize response time as applications search for, retrieve and write data. Bottlenecks in the I/O path can be detrimental to database response time, quickly affecting a corporation's bottom line. A 4Gb/s connectivity infrastructure is not always a limiting factor, but can be a contributing factor to poor response time. Furthermore, virtualization can also contribute to reduced I/O throughput and response time. However, with proper tuning, technology and connectivity products, I/O need not suffer. This section provides details on the Best Practices aimed at optimizing I/O throughput and response times in traditional and virtual server Oracle deployments.

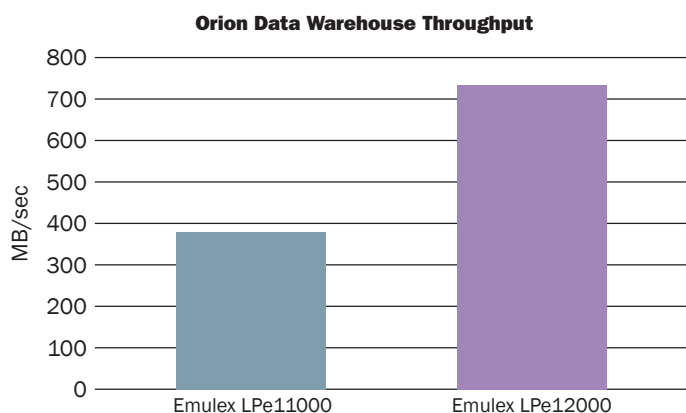
# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

## 1.1 Best Practice—Implement 8Gb/s Fibre Channel HBA in 4Gb/s Fibre Channel environment

If your connectivity is based on 4Gb/s Fibre Channel, your I/O throughput and response time will benefit by upgrading to 8Gb/s Fibre Channel HBAs. Benchmark tests show that implementing 8Gb/s Fibre Channel HBAs in a 4Gb/s environment increases overall performance for data warehousing and OLTP.

**Data warehousing benchmark performance**—Data warehousing (DW) as an I/O workload is characterized by requiring very large data throughput due to its large sequential I/O profile. Using Orion, a tool available from Oracle that simulates Oracle I/O workloads, a DW simulation was performed with Oracle database I/O libraries and large I/Os to simulate data warehouses.

The Orion DW test illustrates that the Emulex 8Gb/s Fibre Channel HBA is capable of sustaining throughput levels that are far beyond that of the 4Gb/s Fibre Channel HBA and nearly capable of the link rate limitation of 8Gb/s Fibre Channel. Figure 1 illustrates the simulated performance differences for a data warehousing I/O profile between the Emulex 4Gb/s LPe11000 HBA and the Emulex 8Gb/s LPe12000 HBA.



**Figure 1** Emulex 4Gb/s vs. 8Gb/s HBA data warehouse throughput performance.

**FCoE performance**—For those moving to converged 10GbE networks, database applications also will benefit from FCoE connectivity. The Emulex OneConnect FCoE CNA is a single-chip, high-performance 10Gb/s Ethernet product platform that provides server connectivity for network and storage traffic and is built to meet the QoS requirements of Oracle users. In fact, the OneConnect FCoE CNA, which is generally available through Emulex's distribution channel, reached 919 thousand Input/Output per second (IOPS) on a single port, more than double the performance of its nearest competitor. For virtualized server environments, this leap in network performance is needed to fully realize the capacity of the new Intel Xeon-based servers, which deliver nine times more performance than the previous generation. As you explore converged networks for your data center, you can rely on Emulex to deliver the high performance its' adapters are known for.

## 1.2 Best Practice—Maximize 8Gb/s Fibre Channel HBA performance with 8Gb/s I/O path

As mentioned above, connectivity performance for your Oracle database is increased when you install 8Gb/s Fibre Channel HBAs in a 4Gb/s infrastructure. However, to get the maximum performance out of your 8Gb/s Fibre Channel HBA, ensure the complete I/O path also runs at 8Gb/s. This includes the switch and array ports. If this can't be provided, then providing multiple paths to differing Logical Unit Numbers (LUNs) can achieve the same result.

## 1.3 Best Practice—Maximize OLTP performance with 8Gb/s Fibre Channel HBA

OLTP workloads, which are characterized by high volumes of transactions that compete for I/O bandwidth, underscore the importance of high IOPS. But I/O response time is the other important performance factor. I/O that completes faster will allow for a greater number of transactions within an acceptable time, thereby increasing productivity within an Oracle environment. This has an immediate impact on the company's bottom line. 8Gb/s Fibre Channel HBAs use faster internal processors which have the effect of processing every I/O slightly faster. This is a contributing factor which helps reduce the total I/O latency even when connected to 4Gb/s SANs.

A Best Practice for OLTP is to construct an I/O subsystem that can achieve a large number of random IOPS at the lowest latency possible. Formerly, an HBA could be tuned to achieve higher IOPS by coalescing I/O operations which also reduced the server CPU load. But this had a potential tradeoff of increasing I/O response time which meant that both benefits were not possible. Emulex developed a feature that delivers the best of both approaches by predicting the server's workload and dynamically adjusting the coalescing parameters. Thus, using this feature, users no longer need to test and tweak these I/O parameters.

Benchmark tests show that the LPe12000 (single-channel) and LPe12002 (dual-channel) 8Gb/s Fibre Channel HBAs from Emulex offer these important advantages for Oracle users:

- **Reduced I/O latency**—Every I/O sent or received from the server is completed notably faster. This is especially beneficial for an Oracle Database, which can be response-time sensitive.
- **Better CPU efficiency**—Fewer CPU resources are used to process I/O, leaving more CPU capacity for applications. This raises the transaction ceiling as much as 33% and provides better throughput for applications with high I/O burst levels.
- **PCI Express 2.0 support**—Enables the capabilities of next generation servers that are likely to be used with new Oracle Database deployments.

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## 1.4 Best Practice—Use NPIV to maximize Oracle performance on virtual machines

As more and more enterprises deploy virtualized servers, I/O performance requires special attention to ensure Oracle QoS requirements are met. In some scenarios, it is important for each VM to have its own identity on the SAN. This allows each VM to have unique zoning and management of storage services. N\_Port ID Virtualization (NPIV) is the T11 standard developed by Emulex and IBM that enables this capability. NPIV can be used to virtualize adapter ports so that each VM connects to the SAN with a unique virtual World Wide Port Name (WWPN). NPIV support is required on both the adapter and fabric switch (see Figure 2).

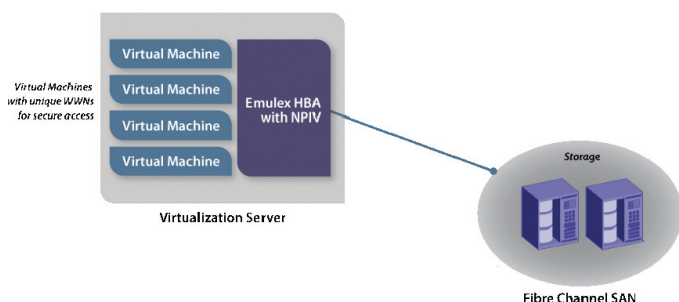


Figure 2 Server and HBA virtualization.

**SAN Best Practices for virtualized servers**—SAN Best Practices are important to any virtual servers deployment in a Fibre Channel SAN. Emulex HBAs with NPIV, coupled with OneCommand Manager, allow the following SAN Best Practices to be used in server virtualization environments:

- **Maximum security with fabric zoning and LUN masking.** Emulex adapters enable each virtual server to be managed separately by allowing each its own address on the Fibre Channel fabric (i.e., allows fabric zoning). Since access to a specific storage LUN is restricted to each OS using the virtual WWN for zoning, access is restricted in the same way as it is restricted to specific physical servers. This results in isolation of all operating systems running on a single physical server, ensuring the highest level of security for the entire system. Furthermore, the systems' overall reliability is maximized as management or operations to one OS cannot affect others running on the same physical server.
- **Greater management capabilities by storage administrators.** Emulex adapters give each guest its own WWN, allowing the storage attached to it to be managed by storage administrators in the same way physical servers are managed. That is, the Oracle Solaris administrator does not have to duplicate storage-centered management tasks.
- **SLA and QoS support.** Fabric management tools from vendors such as Cisco and Brocade provide the means to prioritize I/O traffic through the SAN Fibre Channel fabric based on the requester (initiator). When coupled with Emulex adapters, these tools provide privileged access to fabric bandwidth, and reduced network latency to

selected OS instances and applications. Additionally, Emulex adapters enable fabric-based accounting, chargeback and troubleshooting tools to operate for each guest, thus ensuring that SLA and QoS requirements for each guest are met, and corresponding resources are measured and charged to the proper cost center.

- **Flexible provisioning and upgrade.** Since zoning and other services are no longer tied to the physical WWN hard-wired to the adapter, it is easier to replace an adapter. You do not have to reconfigure the SAN storage, because the new server can be pre-provisioned independently of the physical adapter WWN.
- **Workload mobility.** The virtual WWN associated with each guest follows it when the guest is migrated across physical servers. All settings, including zone membership, LUN masking and fabric priority, are thereby automatically carried over. No SAN reconfiguration is necessary when the workload is relocated to a new server.

## 1.5 Best Practice—Use dual port and quad port HBAs to maximize Oracle performance on virtual machines

Dual port and quad port performance is critical in a virtualized environment. As the number of VMs in a single server increase, so do the I/O requirements of the host (physical) server. As I/O traffic is consolidated from multiple VMs onto a single HBA, greater per port performance is required.

In a recent benchmark of dual port HBAs, Emulex LightPulse Dual-Channel 8Gb/s Fibre Channel HBAs delivered higher overall throughput and transaction rates than the nearest competitor. Figure 3 compares the IOPS capabilities of the available Fibre Channel 8Gb/s Fibre Channel HBAs. The vertical bars represent the HBA's overall IOPS performance, while the bottom segments show IOPS performance of the first channel and the top segments show IOPS performance of the second channel. It is clear to see that the Emulex LightPulse LPe12002 8Gb/s Fibre Channel HBA is effectively using its second channel to outperform a similar HBA by 127%.

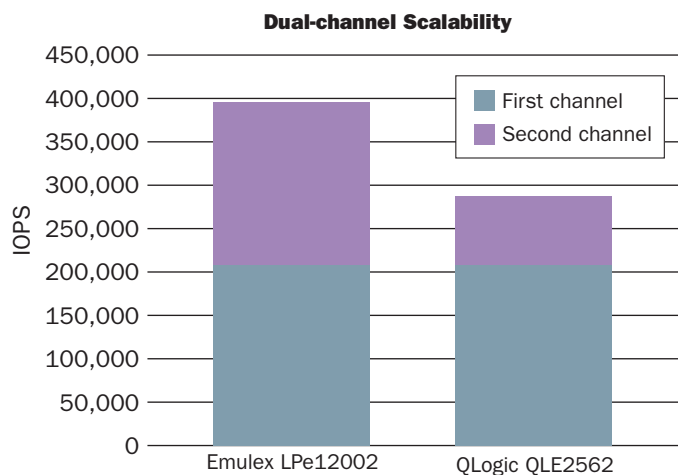


Figure 3 Emulex delivers greater IOPS on second channel.



# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

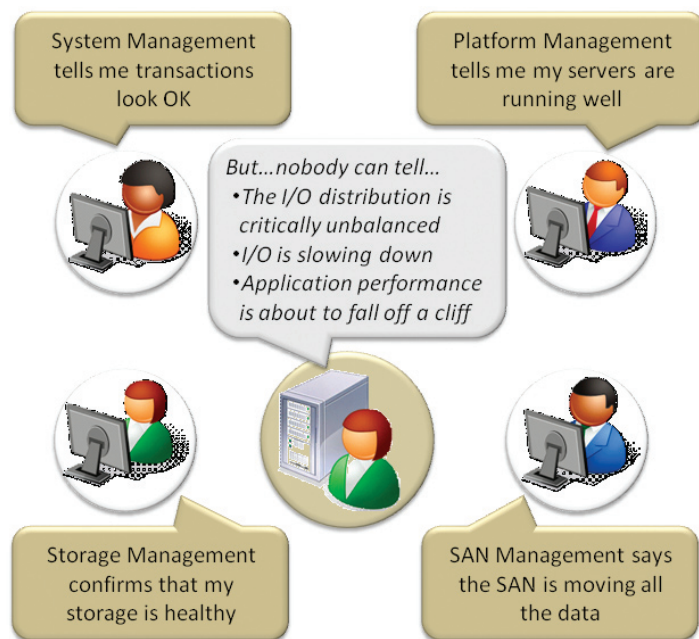
Emulex LPe12002 8Gb/s PCIe 2.0 Fibre Channel HBA offers the highest performance for critical Oracle business applications used with a virtual server compared to the QLogic QLE2562 HBA:

- 127% better second channel scalability as measured in IOPS
- 37% greater total IOPS when saturating both channels
- 33% more effective CPU utilization
- 15% greater transaction performance
- 115MB/s more bandwidth

These advantages result in optimal slot utilization, as well as a reduction in the total number of HBAs required, and help meet QoS requirements.

## 1.6 Best Practice—Manage and tune real-time I/O performance

Oracle customers need real-time analysis for I/O performance to ensure OLTP and OLAP are achieving peak QoS performance. As shown in Figure 4, it is often difficult to know where I/O problems occur.

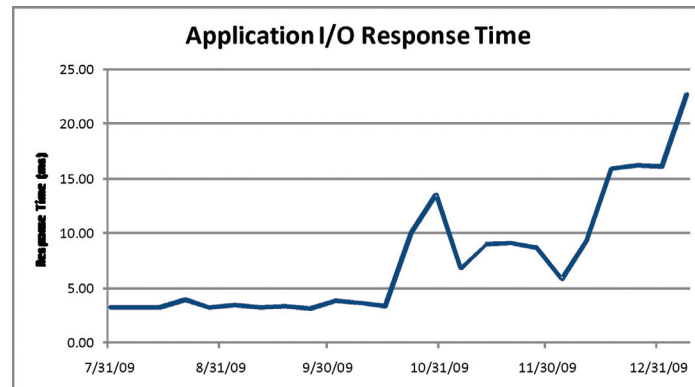


**Figure 4** Isolating I/O related performance issues can be difficult.

As data centers become more complex, Oracle users can benefit from real-time, as well as historical data, about end-to-end I/O performance. OneCommand Vision I/O Management application provides detailed I/O related data which can be used to address, or even avert, I/O bottlenecks, helping Oracle users maintain the highest level of application performance while maximizing utilization of existing resources. OneCommand vision delivers the following advantages:

- Introduce I/O management—a missing component in the management toolbox
- Improve asset utilization and reduce capital expenditures
- Increase application performance
- Deliver on SLA commitments
- Provide scalable, heterogeneous support
- Reduce I/O bottlenecks
- Increase management efficiency and reduce operational costs

I/O management is a critical tool for optimization of performance and maximization of resources within a data center. Figure 5 shows an example of the type of information OneCommand Vision provides:



**Figure 5** Application I/O response time increasing.

There are many reasons why your I/O response time is not where you want it to be. OneCommand Vision will provide you the information you need to see about what is happening with your I/O response time, today and historically, and give you information on how to fix it.

OneCommand Vision's pure software architecture easily scales with the data center and does not require installation of in-line hardware components.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

## 1.7 Best Practice—Always download the latest Emulex driver when installing and configuring an HBA

Data center administrators know that a highly reliable software architecture is critical to the foundation of an enterprise SAN and to meeting Oracle QoS requirements. Providing the latest I/O features for the Emulex HBA and CNA, the Emulex software stack features:

- A single adapter driver model ensuring that one driver supports all generations of Emulex LightPulse HBAs, FCoE CNAs and OneConnect UCNAs. The single driver model preserves IT investment by taking advantage of new features and OS versions delivered through new driver releases across all Emulex adapters. A single driver simplifies management and reduces operating costs by eliminating the need to maintain complex driver/hardware compatibility matrices (see Figure 6).
- Service Level Interface (SLI™) allowing new firmware releases to be deployed on one server or throughout the network without rebooting. New firmware releases translate into new functionality and enhanced performance.
- Consistency between “In Box” native Fibre Channel drivers included with the OS distributions and the driver certified by leading server and storage vendors. One driver gives end users support continuity (without finger pointing) and interoperability between server, storage and OS distribution suppliers.

To ensure you have the latest features for your Oracle environment, download the latest Emulex driver kit from the Emulex web site: <http://www.emulex.com/support/>

The driver kit contains the Emulex driver in an RPM package.

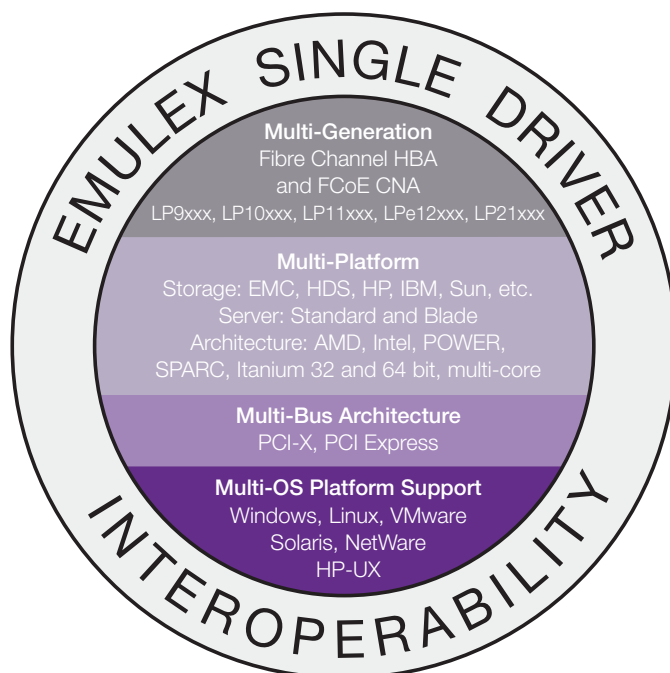


Figure 6 Emulex single driver model.

**Driver configuration tips**—The Emulex driver is configured by default to achieve the best performance for most conditions. Although there are many driver parameter settings that can be modified with OneCommand, only a few might interest a typical Oracle user:

- **Link speed**—Emulex HBAs are capable of running at different link speeds. For example, an 8Gb/s Fibre Channel HBA can also run at 4Gb/s and 2Gb/s. The default behavior is to set the speed automatically. In this case, a query is done to determine the link speeds that the switch supports and the highest mutually supported link speed is used. In unusual cases, excessive errors may occur at the maximum possible speed. These errors are resolved by resending the data, but the overall effect could be a reduction in throughput. In these cases, the link speed can be set to a lower speed to reduce errors and retransmissions.
- **Interrupt coalescing**—The Emulex driver transfers data to the CPU by doing an interrupt, which notifies the CPU that data is available. With interrupt coalescing, multiple interrupts can be batched together so that transfers can be done more efficiently. This is particularly beneficial with higher I/O rates where more data can be transferred with each interrupt. With lower I/O rates, it's better to send the interrupts sooner rather than wait for more data to arrive for transfer. By default, auto-coalescing is turned on and recommended, enabling the driver to process interrupts based on the I/O rate. However, in some cases it may be advantageous to specifically set the parameters that control interrupt coalescing. See the OneCommand User Manual for full details.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

## 2. Best Practices to reduce costs (server, licensing, management, security) while maximizing server performance

Oracle applications require robust server products that can handle the high I/O requirements of OLTP and OLAP. CPU processing that does not contribute directly to I/O transactions is a drain on actual Oracle database performance and could require additional servers to maintain the desired performance level. With an eye on stretching limited IT dollars and reducing Capital Expenses (CapEx) and Operating Expenses (OpEx), this section provides details on the Best Practices aimed at reducing costs associated with server acquisition and management, as well as security.

### 2.1 Best Practice—Tune your 8Gb/s Fibre Channel HBA for maximum performance

As described previously, your Oracle database applications can benefit greatly by installing 8Gb/s Fibre Channel HBAs into your connectivity infrastructure. Tuning your 8Gb/s Fibre Channel HBA for maximum performance is also critical.

To understand how to tune your I/O subsystem for Oracle Database, you must first understand what elements are important for the database to perform well. Database activity is measured in time, both time spent in CPU, as well as I/O time. A database user measures acceptable database performance by how fast their query returns or submits information. DBAs must design their database solution to run at the maximum expected user load at an acceptable response to the users.

In analyzing database performance issues, it is important to gather data that shows the trend of where time is being spent. Oracle Enterprise Manager is a great tool for breaking this out. In the Performance section, the Average Active Sessions graph (see Figure 7) gives you a trend line over time of where database time is being spent, whether it is on CPU, I/O, network, memory or elsewhere. The goal in tuning the I/O subsystem is ensuring that I/O time is not the bottleneck that is leading to poor database performance or high transaction response.

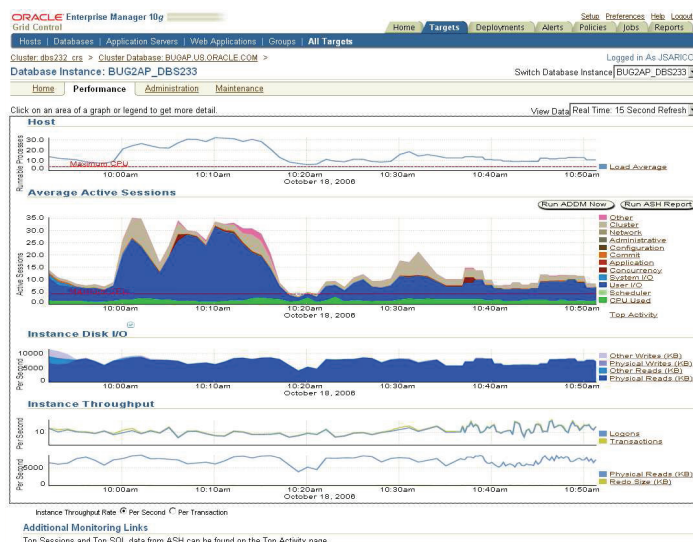


Figure 7 Oracle Enterprise Manager.

A database I/O subsystem is comprised of components on the hosts, SAN and storage array. The general priority for establishing adequate transaction performance starts at the disk array. Choices made to the number of disk spindles and RAID choice will generally have the most profound direct impact to database transaction performance for OLTP. Link speed of HBAs, switches and array ports will have a direct impact on data warehousing performance.

When selecting an HBA for an Oracle database server, generally the higher the link speed, the better performance from the I/O subsystem. The higher links speeds will allow for lower database time in data warehousing queries due to the increase in throughput potential of the higher data rate. But higher link rate HBAs also usually incorporate internal processors that increase transaction performance and lower latencies.

The host side Queue Depth HBA parameter is another parameter that may affect the I/O subsystem performance. This parameter is generally used as a safeguard to prevent too many I/O requests from flooding the target port on the array. When an array port becomes over-subscribed, it becomes increasingly inefficient. In the case where multiple host systems are connected via a switch to the same array port, it may be necessary to slow host ports down to prevent the overload on the target. This is done by reducing the HBA Queue Depth parameters on the hosts. On I/O subsystems that multiple hosts do not share, an array greater host queuing may help to achieve better I/O performance. This is achieved by increasing the HBA Queue Depth parameter.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

## 2.2 Best Practice—Increase operational efficiency with management solution

In today's IT environments, data center administrators are challenged to deploy, monitor and control extensive networking resources to meet QoS requirements. Enterprises that rely on Oracle applications in traditional and virtual environments need a management framework that is flexible, scalable and integrated with key industry initiatives. Figure 8 provides a framework management architecture based on Emulex OneCommand.

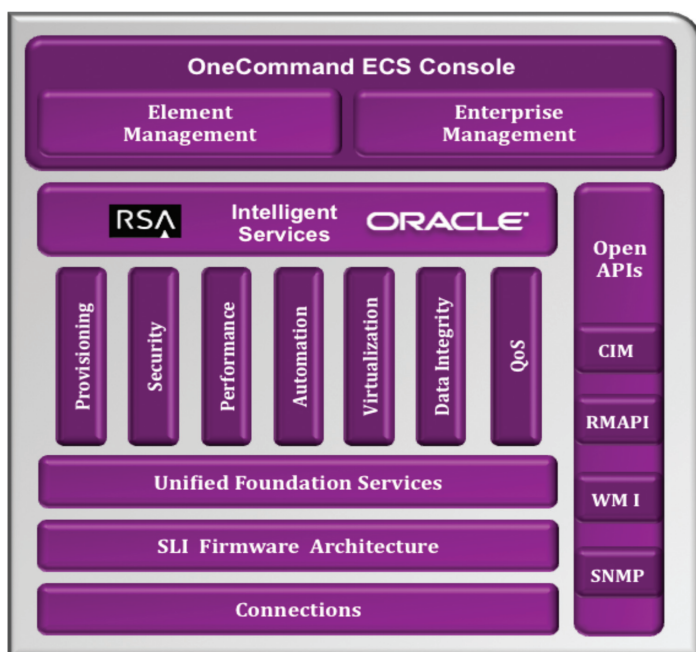


Figure 8 OneCommand framework architecture.

With a management solution, such as OneCommand, you will achieve greater operational efficiencies, with the ability to manage HBAs and CNAs, no matter where they are located, what platform they are running on, or how they can be accessed—whether in-band (over the Fibre Channel link, an exclusive feature of Emulex) or out-of-band (over the local area network). Testing has shown that by using OneCommand Manager, administrators can get twice the adapter management functionality in half the time compared to other management solutions (see Chart 1 and go to the OneCommand Manager Report Card on [emulex.com](http://emulex.com) for more details). In an enterprise setting with hundreds or even thousands of adapters, the productivity advantage is significant.

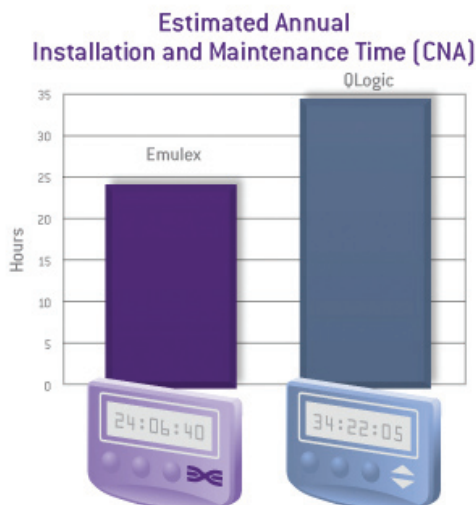


Chart 1 Management efficiency comparison of the time it takes annually to manage 175 CNA ports using Emulex OneCommand Manager versus QLogic SANsurfer. Per this chart, it would take 24 hours to install and manage 175 Emulex OneConnect 10Gb Ethernet (10GbE) CNAs compared to 34 hours to install and manage QLogic CNAs.

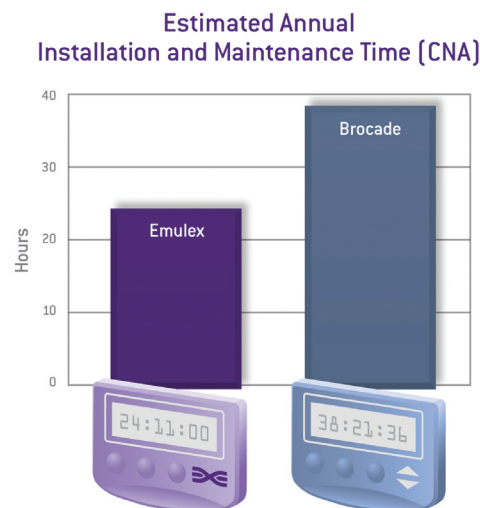


Chart 2 Management efficiency comparison of the time it takes annually to manage 175 CNA ports using Emulex OneCommand Manager versus Brocade HCM. Per this chart, it would take 24 hours to install and manage 175 Emulex OneConnect 10Gb Ethernet (10GbE) CNAs compared to 38 hours to install and manage Brocade CNAs.



# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

Emulex OneCommand Manager delivers the following key features to help Oracle users meet QoS requirements:

- Discovery and management of virtual ports residing on Emulex Fibre Channel HBAs and FCoE CNAs
- Automation of key management tasks for unparalleled HBA and CNA configuration and management efficiency. Driver profiles, which contain the driver's parameter settings, can be replicated and efficiently applied to other HBAs and CNAs in a single step
- Batch mode propagation of driver profiles and firmware versions effortlessly across the SAN
- Scriptable command-line interface giving storage administrators the flexibility to tailor or automate their adapter management actions using customized scripts
- Robust SAN troubleshooting—Emulex LightPulse adapters are designed to assist with troubleshooting and to minimize the impact of field upgrades
- HBA and CNA beaconing facilitates physical identification of an adapter within a server by distinctive flashing of the adapter's LEDs
- Robust online diagnostic functions (such as various loop back tests), warm Power-On Self-Tests, and end-to-end diagnostic functions to validate connectivity across the fabric
- Streamlined replacement, avoiding configuration errors. Emulex LightPulse adapters store port parameters on the host, so that when an adapter is replaced, the parameters associated with the previous port are automatically applied to the replacement adapter without user involvement

## 2.3 Best Practice—Use GUI, Linux sample scripts and customized scripts

To best meet QoS requirements, you can turn to tools, such as the OneCommand Manager application, developed by working with IT professionals focused on improving operational efficiencies. Moreover, the OneCommand Command Line Interface (CLI) supports all of the basic commands that are available in the OneCommand Manager GUI. The CLI requires no user interaction, allowing commands to be integrated into scripts to automate management functions. Emulex also provides powerful Linux script examples that can be downloaded at:

[www.emulex.com/downloads/emulex/cnas-and-hbas/drivers/linux.html](http://www.emulex.com/downloads/emulex/cnas-and-hbas/drivers/linux.html)

By using these tools, built and provided by IT professionals, you can improve the operational efficiency of your data center, reducing OpEx.

## 2.4 Best Practice—Offload encryption processing to the OneSecure adapter for a cost-effective security solution with zero impact to applications processing

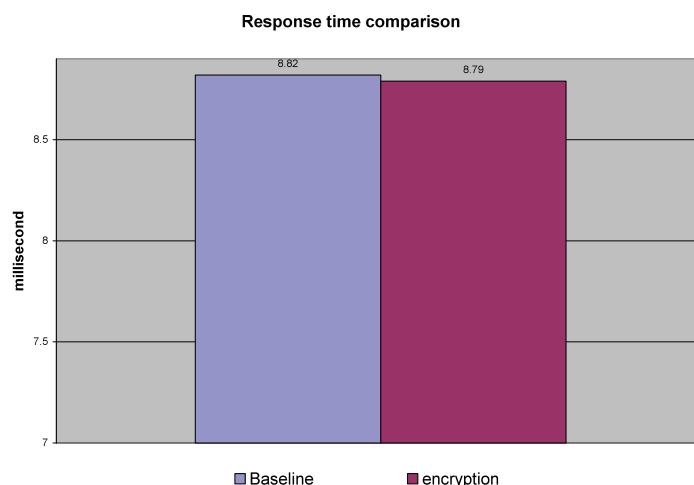
By offloading encryption processing to the OneSecure adapter, two goals are met simultaneously.

Firstly, encryption HBAs provide a more cost-effective solution, having the following cost advantages over other methods:

- 30% less expensive than disk shredding
- 50% less expensive than encryption arrays
- 70% less expensive than encryption switches
- Reduces the number of applications licenses that need to be purchased

There is no need to rip and replace current storage systems, or purchase expensive encryption appliances that do not scale and add complexity to the storage environment. OneSecure encrypts data on most storage arrays, which protects disks in the event of unauthorized access or disk removal. This also means disk shredding is no longer necessary, because the data on disk is unreadable and encryption keys are securely stored on the key manager.

Secondly, when OneSecure is running encryption, it has zero impact to the server CPU so application processing is not impacted. Figure 9 is from a recent EMC benchmark test using Oracle Database 11g R2 and shows the difference in response time when encryption is enabled and when it is not.



**Figure 9** Response time comparison of baseline without encryption compared to Emulex HBA with CLARiiON® Host Encryption.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

## 3. Best Practices to ensure regulatory compliance for sensitive data workloads

QoS requirements now encompass data security and regulatory compliance. Breaches in data security can be devastating to a business. Data security is a growing concern with 261 million data record breaches occurring since 2005. The risk is real and can affect organizations of any size, location or industry. Organizations need to comply with a variety of regulatory and disclosure requirements for data security. Governments have enacted a variety of strict security regulations mandating the privacy and integrity of sensitive customer and corporate data (e.g., with Health Insurance Portability and Accountability Act [HIPAA], European Union Data Protection Directive [EUDPD], or Payment Card Industry Data Security Standard [PCIDSS]).

Figure 10 illustrates the I/O stack in a typical Oracle environment. Note that one of the key components is the Oracle Automatic Storage Management (ASM) subsystem, which is the interface between an Oracle database and the operating system.

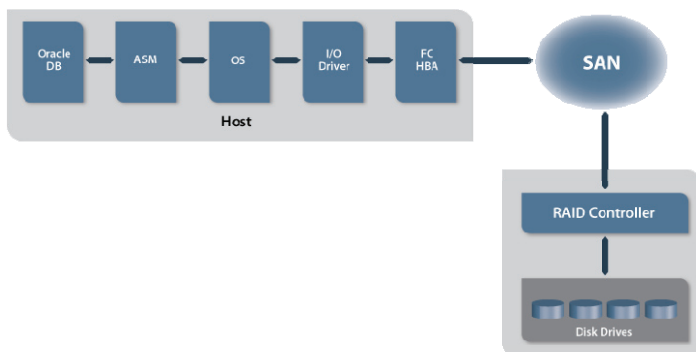


Figure 10 Software and hardware components in the I/O stack.

Physical data integrity relates to the integrity of data as it travels the I/O path between an application on a server and disk drives on a storage array. The Best Practices in this section focus on ensuring compliance for sensitive data workloads as they reside on the database and travel through the I/O path.

### 3.1 Best Practice—Secure data both in-flight and at-rest on disk

Meeting regulatory requirements in an Oracle environment can be achieved through a number of options, either using hardware, software or a combination. The best solution to accomplish security and compliance objectives is one that provides 100% end-to-end protection. Host-based encryption is the best method because it minimizes the window of vulnerability, providing the compliance strategy that security-conscious companies need. Data is protected from the time it leaves the server, no matter where it goes, to the time it is used again. OneSecure is an easy to implement, drop-in solution that enables compliance with internal, private and government standards (PCI-DSS, HIPAA, HiTECH, Basel II and more).

OneSecure encrypts with AES-256 bit encryption and is optimized for virtualized environments. Enterprise-wide key management enables VM migration with encrypted storage ready for use (see Figure 11).

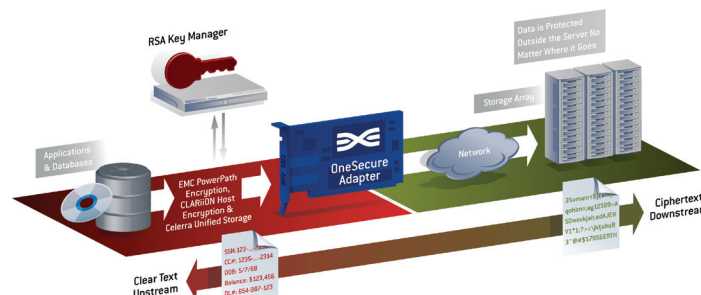


Figure 11 Emulex OneSecure data encryption solution.

### 3.2 Best Practice—Encrypt data as close to where data is created...at the host

Because OneSecure encrypts as close to where data is created as possible, at the host, it meets the Storage Networking Industry Association (SNIA) best practices standard for encryption.

### 3.3 Best Practice—Hardware protection of encryption keys

OneSecure supports the National Institute of Standards and Technology (NIST) requirements for hardware protection of keys. Keys are wrapped and kept inside a FIPS 140-2 protected boundary.

**Data integrity**—One of the concerns for database administrators is the integrity of data as it travels the I/O path between applications on a server and disk drives on a storage array. Although “silent”, undetected data corruption is rare, the costs can be extremely high. Emulex is working with Oracle to provide new levels of data checking beyond the Cyclic Redundancy Check (CRC) that is done to verify data within an Emulex HBA. This new technology is based on appending extra information, referred to as integrity metadata, to each 512-byte data block. When fully implemented, there will be two parts to the complete solution. The following descriptions are based on data writes. The reverse would apply for data reads.

- **Data Integrity Extensions (DIX)**—Integrity metadata is added for each data block by Oracle ASM. For the release described below, a Transmission Control Protocol (TCP) checksum is added. Emulex 8Gb/s Fibre Channel HBAs use the TCP checksum to verify the incoming data block. Oracle submitted an integrity-capable block I/O layer to the Linux kernel, which is now available in Oracle Enterprise Linux
- **Protection Information (PI)**—A CRC checksum is generated by Emulex 8Gb/s Fibre Channel HBAs that replaces the TCP checksum. The CRC checksum is verified by the storage array before data is written to a disk.

# Deployment New I/O Management Best Practices for Oracle® Database Quality of Service

Oracle and Emulex have announced the Extended Data Integrity program that provides DIX support. Emulex and Oracle are working with other storage partners to deliver a full end-to-end solution that supports both DIX and PI. With the Oracle “optimized kernel” version of Oracle Enterprise Linux, Data Integrity is quickly becoming a reality.

### 3.4 Best Practice—Use standards-based security solutions for interoperability

Enterprises today have very diverse and rapidly changing environments. Many times, multiple encryption solutions have been implemented as a result of different regulations or requirements. By standardizing on a single security solution, such as the Emulex OneSecure 8Gb/s Fibre Channel HBA, you get the security you need without the management impact of multiple solutions in place. OneSecure supports open enterprise key management with:

- Support for the OASIS KMIP specification (Key Management Interface Protocol) for interoperability
- Partnership with RSA—the leader in enterprise security
- Partnership with IBM Tivoli Key Lifecycle Manager (TKLM)—enterprise key management solution

### Conclusion

Emulex and Oracle offer enterprises leading solutions to maximize I/O performance for OLTP and OLAP systems in traditional and virtual server environments. These solutions also help keep CapEx and OpEx low by limiting the number of servers required to meet QoS requirements. Management and security solutions also contribute to lower CapEx and OpEx. The 15 Best Practices provided in this White Paper describe the best ways to optimize an Oracle environment. Just as they did with Data Integrity, look to Emulex and Oracle to continue to focus on the most pressing needs of enterprise data centers.

For more information regarding Emulex I/O connectivity solutions, visit:

[www.emulex.com](http://www.emulex.com)

For more information regarding specific Emulex and Oracle solutions, visit:

[www.emulex.com/solutions/oracle/resources-and-tools/emulex.html](http://www.emulex.com/solutions/oracle/resources-and-tools/emulex.html)

For more information regarding Oracle solutions, visit:

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